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REINFORCED CONCRETE PRESSURE PIPE¹

BY COLEMAN MERIWETHER

Although concrete was used as long ago as 2300 years to build an aqueduct for the city of Carthage and later for the construction of aqueducts for Rome, it is only recently that pre-cast reinforced concrete pipe has been developed to meet the principal requirements of pressure lines. Experience gained lately shows that concrete properly made and sufficiently reinforced will resist safely internal and external stresses up to 100 pounds per square inch. Correct methods of manufacture will produce pipe with a low coefficient of friction, experience having shown that a greater discharge was obtained from concrete lines than was anticipated. Leakage through the walls of pre-cast pipe has been almost nil and leakage through the joints has been less than is usually allowable for water mains.

As the construction of pipe lines is usually carried on at temperatures higher than that of the water which will flow through the conduits, it necessarily follows that contraction will occur. This will produce cracks at the joints through which considerable leakage will occur if provision has not been made to care for the contraction.

It may be assumed that the maximum temperature at the time of construction will be near 100° F. and that during the winter in some parts of North America the temperature will drop as low as 50° or more below zero. Pipe lines should be covered with the earth backfill before work is suspended for the winter and all openings in the pipe line should be tightly closed to prevent circulation of air in the conduit. With such precautions the temperature of the pipe line is not likely to drop below 40° F. Flowing water will have a temperature very little under 32° F. The above assumptions will give an idea of the range of temperatures and the consequent contraction and expansion in water conduits.

¹ Read before the Illinois Section, April 16, 1918.

One of the joints now used, figure 1, is constructed with a crimped copper band which is continuous throughout the circumference of the joint. As the pipe contracts the crimp opens and as the pipe expands the crimp closes. This joint is used in pipes 36 to 108 inches in diameter and is a true expansion joint, having been found successful in different parts of North America. To reduce the number of joints it is well to make the pipes as long as is practicable and trench conditions such as bracing, etc., may be limiting factors. The practice so far has been to make pre-cast units of a maximum laying length of 8 feet. It has also been determined in practice that it is necessary to equip each pre-cast unit with the copper expansion joint.

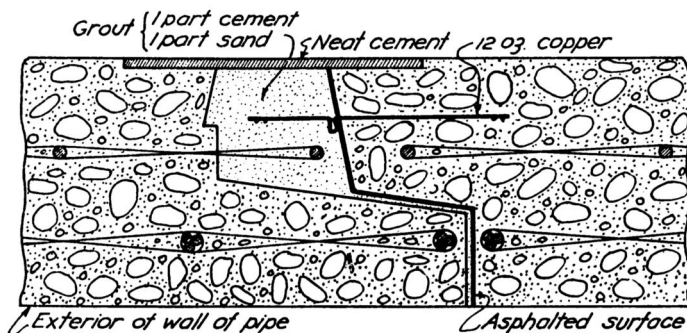


FIG. 1. EXPANSION JOINT.

The installation of a plant for manufacturing 66-inch reinforced concrete pressure pipe for 10 miles of the Greater Winnipeg water conduit in Manitoba, Canada, and some of the details of manufacture are described below. The layout of such a plant is a matter of no small importance, for incessant care must be used in all the details from the installation of the plant and its equipment until the last pipe is laid and the line tested.

Pipe are cast on end and the molds of sheet steel and cast iron must be erected on substantial foundations of reinforced concrete, the surface of the foundations being truly level and finished smoothly so that when the cast iron base mold is set and the sheet steel casings are erected the casings will be truly vertical.

The process of assembling consists, first, of cleaning, oiling and setting the cast iron bases on the concrete foundations. Second, the inner sheet steel casings are set on the bases and on top of them

is placed a steel filling platform used to center and hold truly circular the inner casings as well as to receive concrete from the conveying buckets. Third, the inner cage of reinforcement is placed, with its bottom strand set in an annular slot in the cast iron base; the slot is then filled with dry sand which forms a core and prevents concrete flowing into the space and thereby binding the base to the pipe. Fourth, the outer cage of reinforcement is set and the outer steel casing placed and clamped. The mold is then ready to receive concrete.

A batch of neat cement grout is dumped on the filling platform and flows into the mold, splashing over the two rings of reinforcement in its descent to the bottom of the mold. There a portion of the grout remains until the first batch of concrete is deposited, when this surplus grout rises with and is incorporated into the concrete and thereby replaces any grout which may have been abstracted from the concrete by the reinforcement. This is necessary to secure a pipe dense throughout its mass. The first batch of concrete is dumped on the filling platform almost as soon as the last of the grout flows into the mold, and each mold is filled very quickly, not enough time elapsing to cause any line of separation between batches. The filling is continuous from start to finish. All parts of the molds are cleaned and oiled between each filling.

In the manufacture of most pre-cast concrete pressure pipe it is necessary to use 1 volume of portland cement, $1\frac{1}{2}$ volumes of sand and $2\frac{1}{2}$ volumes of coarse aggregate; this means that $2\frac{1}{2}$ barrels or 950 pounds of cement is used per cubic yard of concrete. In the manufacture of pre-cast pipe for the Winnipeg Aqueduct it was found necessary to use but one sack of cement to 3.8 cubic feet of mixed aggregate, or approximately 2 barrels or 700 pounds of cement per cubic yard of concrete. (The Canadian barrel weighs 350 pounds gross or 346 pounds net.) This small quantity of cement was found sufficient because of the very excellent grading of the mixed aggregate. The concrete is mixed to a quaking or jellylike consistency, which will easily flow into place when slightly puddled.

On the Winnipeg work, the concrete was mixed in batch mixers at each end of the manufacturing plant, and after being dumped into conical buckets was transported by traveling derricks to the molds. A simple ball valve easily and accurately controlled the flow of concrete from the buckets, which carried grout, concrete and

mortar equally well. Molds were filled simultaneously in pairs, one member of each pair being on opposite sides of the derrick track, which was located in the center of the manufacturing site.

When the concrete in the molds reached the top of the outer casing, a cast iron spigot ring was set and the spigot mortar deposited, tamped in place and the copper expansion joint set.

The mortar for spigots on this contract is made of 1 part cement to 2 parts sand. It is mixed to the same consistency as the concrete so as to obtain the same rate of setting and settlement, as nearly as possible. As the spigot mortar settles, more mortar is added until the settlement ceases, when the joint is finished.

Each expansion joint is mounted on a steel spider which remains in position until the concrete has set and the forms are to be stripped from the pipe. The spider is centered accurately by means of a pin and a hole in the center of the filling platform.

To maintain a constant and uniform rate of setting in the concrete, as well as to protect the concrete from the low night temperatures sometimes attained in Canada, wet steam was used in order to obtain a moist, warm atmosphere about the pipes. The steam mains were laid underground in a way to prevent excessive radiation as well as to place them out of the way. A riser connected each steaming set of five vertical jets with the mains. One of the jets was placed in the center of the concrete foundation so as to be in the center of the cast iron base and the other four jets were spaced equidistant around the circumference of the base, sufficient space being allowed for clearance between the jets and the edge of the base. To confine the steam to the pipes, canvas jackets and hoods were used, the jackets being suspended by hooks from an iron pipe ring supported on two hard wood arms which were raised above the copper expansion joint strip by hard wood blocks on each end of the arms. The jackets were laced vertically and a canvas hood placed over the top of the steam cover spider, the wood arms and the iron ring of the spider preventing the hood from resting on the light copper expansion joint. The hood was tied to the jacket by means of rope and rings, and the jackets were held snugly in place by rope run through eye-bolts secured in the concrete bases. The canvas steam covers were removed with the spider when the forms were stripped, and were replaced as soon as the casings had been removed. The steam was again turned on and the pipe steamed for three to four days.

Leakage tests on completed pressure conduits

LOCATION	DIAMETER	LENGTH OF LINE	PRESSURE HEAD	LEAKAGE	
				Per 1000	Per mile
	<i>inches</i>	<i>feet</i>	<i>feet</i>	<i>gallons</i>	<i>gallons</i>
Baltimore, Md.....	108 and 84	8,700	82	1,494	7,888
Dallas, Tex.....	36	14,000	70	121	639
Ft. Worth, Tex.....	36 and 48	1,200	70	1,143	6,035
Seattle,* Wash.....	42	12,800 8,000	135		

*The pipe line in Seattle was a trunk water conduit to operate under a head of 90 feet and every pipe was tested to 135 pounds pressure. Tests were made on short sections of completed line and the leakage was nil.

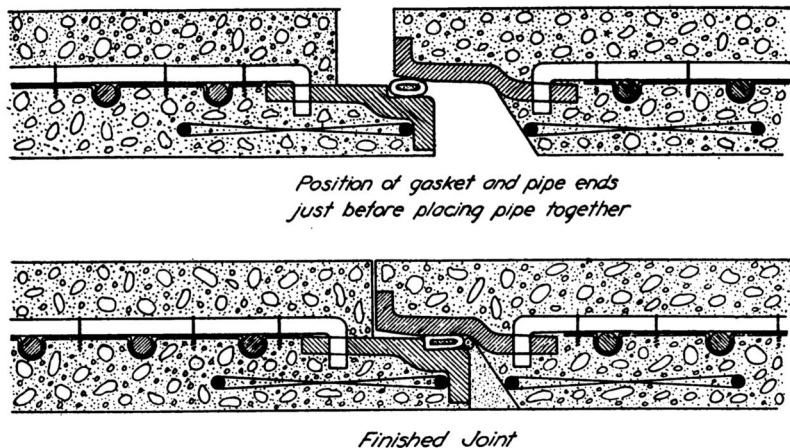


FIG. 2. NEW TYPE OF JOINT.

All that has been said heretofore refers particularly to the copper expansion joint type of reinforced concrete pressure pipe. There has recently been developed a new type of expansion joint, and at the time of writing this paper reinforced concrete pressure pipe 36 inches in diameter with this type of joint has been manufactured and tested with satisfactory results.

It is proposed to construct reinforced concrete pressure pipe 10 to 48 inches in diameter and 12 feet long, each section being provided with a cast iron spigot ring at one end and a cast iron bell ring at the other, the rings being cast integrally with the concrete. Figure 2 shows the joint. The faces of the rings which bear upon

the lead gasket will be accurately machined, providing a very true circular surface. The spigot ring is provided with a seat for the lead gasket, the face of which seat forms half of a dovetail, the object being to provide a greater thickness of gasket at the seat of the dovetail. This prevents the gasket being withdrawn when the pipe contracts or when the pipe is deflected.

The lead gasket consists of a lead pipe filled with compressed fiber and then flattened to an elliptical section, the proper length of gasket being turned to a circle, which is joined forming a ring. This ring is placed in the bell and the pipe is then ready to receive the spigot end of the next pipe to be laid. As the pipes are shoved home the lead gasket is changed from the elliptical section to a section which fills the dovetail space and the space between the dovetail of the bell and the outer face of the spigot. After this has been done a light rope of cotton or jute is placed and a weak joint filler of cement mortar is applied, filling the calking space. This space is provided in the event it should be necessary to calk the lead gasket joint. Such calking is not expected to be necessary.